

## TWENTY FIFTH D.O.D. EXPLOSIVES SAFETY SEMINAR

# REDUCTION OF HAZARD ZONES BY UNCOUPLING BETWEEN MUNITIONS

By

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### Abstract :

For determining the Maximum Credible Event concerning a munitions production or storage facility, it is necessary to take account of the N.E.Q. of all the mass detonating munitions located in the immediate neighbourhood of the donor.

Safety distances which will be determined (Q/D factor) will be those of 1.1 division. This risk division induces highest constraints. Uncoupling between munitions allows to reduce safety distances with important benefits by suppressing sympathetic detonation.

Different means can be used, specially like specific packaging, venting devices, or intrinsic characteristics of insensitive munitions.

This paper shows tests realized by GIAT Industries / Ammunition and Pyrotechnics Division with different types of munitions and main results obtained.

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# **I INTRODUCTION**

Any activity concerning munitions means a risk level. The risk is defined as a notion with two dimensions which are gravity (consequences) and probability. The risk characterizes an inadvertent hazardous event. For any installation of munitions, the inadvertent hazardous event must be located on the basis of the Maximum Credible Event (MCE) : the worst single event that is likely to occur from a given quantity and disposition of ammunition and explosives (Ref 2). Then, it is fitting to estimate the acceptable risk for the individual man, the manufacturer or the Armed Forces, the society.

Today, the public is concerned by safety of persons, property and environment and bring pressure on administration. It induces to obligatory size measures in order to assure safety of munitions facilities at one and the same time for logistical, tactical or operational phasis.

Safety goes by distances between potential explosion seat (P.E.S.) and exposed seat (E.S.). But these distances become less and less compatible with urbanization which is growing up near military installations.

It is necessary to search for all the means allowing to maintain the operational potential and to guarantee the safety of neighbouring installations of P.E.S.

# **II DETERMINATION OF SAFETY DISTANCES**

The principles allowing to determinate safety distances are harmonized into NATO's countries on the basis of the A/C 258/D 258 manual.

Thereby, there is no important divergence between national regulations (ex D.O.D. 6055.9 for the USA and ministerial order of the 26th September 1980 "rules for determining safe distances of explosive facilities" in France).

Safety of munitions facilities is organized according to the following criteria :

- \* Class/division and compatibility group classification
- \* Possible protections existing to the P.E.S.
- \* Separation distances

Q/D criteria is the minimum distance between a P.E.S. and an E.S. It is based on an acceptable risk to life and property from the effect of a mass fire or an explosion (Ref 1).

At this distance, the exposed seat is normally submitted to an acceptable risk. "Q" means the net quantity of explosive (NEQ) generally expressed in TNT equivalent weight, susceptible to be located into P.E.S., it sizes the M.C.E.

"D" varies according to the class/division, characteristics of the P.E.S., nature of E.S., and the orientation of P.E.S./E.S.

Most of munitions in service into Armed Forces at the present time are classified into the 1.1 class/division because they present a hazard of mass detonation. But the mass detonation is the worst accident which could occur with munitions, what lead to the worst Q/D.

Although this paper be limited to the logistical aspects, it is necessary to speak about tactical and operationnal phasis.

At once, during operational phase, a troop carries explosive munitions, and the carried stock must take account of the attrition rate due to enemy actions.

Indeed, due to mass detonation, if a vehicle is hit by a projectile, the stock it carries, and may be the entire stock carried, will detonate dragging important losses.

Concerning tanks, combats during "Desert Storm" have shown that when a tank is hit by an APFDS or a shaped charge, the initial damages are significantly increased by the ammunition reserve explosion, resulting in the turret being blown off.

It is the same thing for tactical facilities. For example, when a hardened aircraft shelter with airborne ammunition inside is hit by Air to ground attack, munitions mass detonation lead to catastrophic results.

The storage of important quantities of munitions which are capable of mass detonating led NATO's countries to set up safety policy based on earth-covered magazines and distances between magazines or between P.E.S. and E.S. Heavy and costly earth-covered magazines like igloos are utilized primarely to prevent propagation of explosion.

NATO AC 258 manual contains all the dispositions adopted by NATO. Some countries believe these rules severe. But in these NATO's countries where these rules are applied, the accidents are extremely rare into storage facilities.

Specialized review recently talked about two accidents which happened in May 1992 :

First one : Explosion at the Commonwealth of independant states pacific fleet ammunition depot of Vladivostok, five injuries, 16 magazines damaged and may be more extensive damages.

Second one : Explosion at a Lybian ammunition depot near Tripoli, 17 persons killed, about one hundred injured.

Explosive munitions can be classified in division 1.1 or 1.2, as they present or not a mass detonation risk. Constraints due to this risk can be easily measured by the obligatory safety distances between the P.E.S. and the E.S.

Thus, the P.E.S. mass detonation risk prohibits storage of munitions into operational installations.

So, it is necessary to store ammunition into isolated munitions storage area. Generally vulnerable to enemies or terrorists actions, it reduces the operational disponibility of forces, increases the risk, especially for handling and transport operations and increases the operating cost of the munitions storage area.

Also for maintenance or manufacturing operations, the growing of the M.C.E. obliges to lay out installations with heavy and costly structures.

### **III SEARCH FOR UNIT RISK**

For lowering constraints, the only way consists to decrease the M.C.E. in order to reach an inadvertent hazardous event which could be acceptable. So, it is necessary to prohibit mass detonation of all the munitions which are in the immediate neighbourhood for limiting the M.C.E., according to circumstances of one stack, one box and if possible only one munition.

For this, the munitions designer can :

- \* Define new methods of operating and storage for limiting stimuli level and consequences of an accidental event in logistical phase.
- \* Develop packaging which offer an efficient and immediatly available protection, against mechanical and thermal stimuli.
- \* Incorporate devices allowing to liberate energy.
- \* Use structures and architectures limiting development of phenomenon.
- \* Use explosives acting with satisfactory making against stimuli.

The munitions designer must be the designer of the new packaging which protect munitions against external stimuli, or the designer of shields which prohibit sympathetic detonation.

For many years, studies and tests made in France and in USA have allowed to know better sympathetic detonation conditions according to :

- \* Space between munitions.

- \* Location of munitions inside packaging.
- \* Nature and thickness of shields.

We realized a lot of tests concerning several families of munitions which allow us today to set solutions answering to the users problems.

### **3.1 Uncoupling tests**

#### **3.1.1 Tests with rifle grenades**

We realized a lot of tests for determining sympathetic detonation conditions with rifle grenades in storage and transport conditions. i.e. in boxes and in palettes with eight boxes. We get a total of two hundred grenades presenting a TNT equivalent weight of 45 Kg.

These tests allowed us to optimize a logistical configuration leading to reduce very much the M.C.E.

With two hundred grenades concerned, only ten maximum are susceptible to detonate presenting an e.TNT < 2.5 Kg, it means 5% of theoretical M.C.E. And then, it allowed us concerning production phase to set up workshops to ensure perfectly operators safety.

#### **3.1.2 Tests with gun ammunition of 35 mm and 40 mm**

For illustrating works we make with gun ammunition, example of tests with gun ammunition of 35 mm and 40 mm.

Gun ammunition surrounded by a cardboard tube are located into a screwed covered wood box. The shield between gun ammunition is made of wood with a thickness of 10 mm. The donor gun ammunition is surrounded by four receivers, two of them are fuseless.

Uncoupling between gun ammunition is effective. Only the donor detonates, what is shown by the metallic sheet located under the box. In these conditions of uncoupling, the M.C.E. is detonation of only one gun ammunition.

#### **3.1.3 Missiles Warheads**

Among tests realized in this area, our works concerning uncoupling between ground to Air missiles are significant.

At the time of these explosive charges fabrication, the mass detonation presented an unacceptable risk for the operators located into the workshop and for the neighbouring installations.

We set up a packaging ensuring uncoupling, thus reducing the hazardous event to the detonation of only one warhead. Many shields have been tested made of wood, composite materials, etc...

The positive result concerning these tests allowed us to take simple and effective actions about safety.

Thanks to this, French Authority approved our safety analysis concerning operators and environment safety.

#### 3.1.4 Anti-tank rockets

We realized tests in order to find the possible best shield between anti-tank rockets. TNT equivalent weight of each rocket is about 2.5 Kg.

The tests concerned sympathetic detonation study with the only launch tube like shield, locating successively rockets in the same way, in opposite way.

At first, we used polyethylene shields with different thicknesses, and finally we used wood shields.

The results of these tests allow us to control non-propagation conditions of detonation in all logistical phase and to set up a packaging limiting to a unit risk.

### 3.2 Venting devices

One of the means allowing the munition designer to limit consequences of an accidental event is to fit the warhead or the rocket motor with venting device. For example, we manufacture the venting device of U.S.A.F. Durandal anti-runway bomb. This system is used in the event of an undesired high temperature. The aim is to prevent a normal propulsive thrust of the R.M. These devices are used to prevent such events from occurring in munitions which are in transport or storage.

### 3.3 Insensitive munitions

Methods we have just seen present very important advantages :

- a) They allow to avoid mass detonation and reduce constraints, more particularly in storage.
- b) They can be used immediatly.



- c) They don't need long and expensive R and D preserving in the same time initial operational performances.

But they are in use just once and their efficiency cannot be guarantee in case of multiple stimuli.

The insensitive munitions take here all their interest as their intrinsic characteristics limit the effects of an accidental event and delete the mass detonation.

Among in progress programs which reduce munitions vulnerability, we produce gun ammunition, grenades, anti-tank rockets, missiles warheads, bombs, example of land mine shows what it is possible to obtain.

After having tested different high explosives and specially several cast or pressed PBX, a land mine has been developed with insensitive munitions capacities.

This mine is mainly composed with a structure, a pressed PBX charge composed of HMX and TATB with the safety and arming unit.

Two series of vulnerability tests have been realized, 12.7 mm bullet impact and sympathetic detonation. The third test, fast cook-off, will be soon realized.

a) 12.7 mm Bullet Impact

Tests procedures : In a packing corresponding with 1H2 UN classification (rigid plastic drum), 5 mines are located vertically, 3 explosive mines and 2 inert mines.

The central mine surrounded by 2 explosive mines is the target. The mines are vertically located. A steel witness plate is positioned beneath the test item. The 12.7 mm are type M2 armor piercing projectile at a velocity of 860 m/s.

Main results : The central mine, hit by the bullet, burns during several seconds after the impact. High explosive burns and the hole created by the bullet acts like a nozzle. The 2 explosive mines in touch with the target do not react. For this test, the passing criteria no reaction more severe than burning is obtained.

b) Sympathetic detonation :

Tests procedures : Two 1H2 UN packages (rigid plastic drum) are located side by side in a natural wood box. The first drum contains 3 explosive mines and 2 inert mines. The second one contains 1 explosive mine and 4 inert mines. The acceptor explosive mine is located in front of the donor mine.

Main results : After the post tests examination, we can note the following results :

- Concerning the 2 neighboring mines, the first one detonates and the second one deflagrates. The acceptor explosive mine located into the neighboring drum has been mechanically broken in small pieces but no explosive reaction or burning occurs.

This land mine presents vulnerability and performances characteristics very interesting due to the HMX/TATB composition.

The tests go on in order to obtain the label "insensitive munitions" in conformity with the Military Standard 2105A and the classification in risk division UN/NATO 1.6.

#### **IV CONSEQUENCES ABOUT SAFETY AREAS**

The interest for the munitions storage area user is to reduce constraints that impose presence of munitions to environment while disposing of maximum storage capacities.

For illustrating the benefit brought by uncoupling between munitions, i.e. the passage from the class division 1.1 to the division 1.2, we can take an example of earth covered magazines like igloos with capacity of 60,000 Kg, on the base of NATO safety distances :

Safety distances to inhabited buildings and public traffic routes :

1.1 division = 870 m (22 Q 1/3)

1.2 division = 500 m

If the existing safety distance separating the P.E.S. from the nearest E.S. is about 500 m, it would be necessary to decrease the igloo capacity from 60,000 Kg to 12,000 Kg in 1.1 division, i.e. divide the storage capacity by 5.

If we take the hypothesis that for 1.6 division, 1.3 division safety distances will be applicable, we obtain for 60,000 Kg :

1.3 or 1.6 division = 255 m

If the P.E.S./E.S. safety distance is always about 500 m, it is possible to store in this case 250,000 Kg, it means twenty times more than 1.1 division.

Safety distances mentionned above are those advised at the present time by NATO.

American and French national regulations are most strict for detailed application. We can think that M.C.E. reduction, more particularly by the uncoupling mean, should form the

subject of safety analysis for determining the maximum hazardous consequences for a given accident.

In effect, uncoupling can be obtained :

- \* Between stacks. For example, into an igloo containing 60,000 Kg, five stacks uncoupled limit the M.C.E. to 12,000 Kg.
- \* Between boxes, the M.C.E. is reduced to the explosive mass contained into the packaging.
- \* Between munitions, the maximum hazard to take into account would be unitary hazard.

## V CONCLUSION

We can see that particularly important perspectives appear for Armed Forces which must :

- \* Improve combat platforms survivability.
- \* Ensure safety in logistical and tactical phase.
- \* Decrease logistical costs.

But it is really necessary to distinguish between near term and long term. Uncoupling between munitions by packaging and / or adapted shields allow to resolve problems met at the present time and particularly during storage phase when reducing :

- \* Safety distances between P.E.S. and E.S.
- \* Risks due to transport and handling imposed by off-site storage.
- \* Operating costs by reduction of necessary areas, undercontrol areas, number of magazines and resistive structures.

Concerning long term, major programs about R and D are on the way to reach to insensitive munitions, and concerning storage phase to classified munitions in 1.6 class division.

Armed Forces must find here same and if possible best performances and money saving upon possession cost.

The job of the munition manufacturer is to answer to his customer troubles, because he knows the munitions characteristics he manufactures. That's what GIAT Industries wants to propose to his customers.

## LIST OF ACRONYMS

<b>M.C.E.</b>	:	Maximum Credible Event
<b>P.E.S.</b>	:	Potential Explosion Site
<b>E.S.</b>	:	Exposed Site
<b>Q/D</b>	:	Quantity Distance
<b>N.E.Q.</b>	:	Net Equivalent Quantity (Kg)
<b>H.A.S.</b>	:	Hardened Aircraft Shelter
<b>I.M.</b>	:	Insensitive Munitions
<b>R.M.</b>	:	Rocket Motor
<b>G.A.</b>	:	Gun Ammunition
<b>C.D.</b>	:	Class Division
<b>e. T.N.T.</b>	:	Equivalent Weight T.N.T.

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